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"TO PROMOTE ECONOMIC CROP PRODUCTION,
IMPROVE THE QUALITY OF THE PRODUCTS, AND
REDUCE WASTAGE IN STORAGE, TRANSIT, AND AT THE MARKET"

STINKING SMUT OF WHEAT - REPORT OF CONFERENCE ON EXTENSION WORK -

AMERICAN PHYTOPATHOLOGICAL SOCIETY, PHILADELPHIA,

DECEMBER 28, 1926

STINKING SMUT OF WHEAT - REPORT OF CONFERENCE ON EXTENSION WORK - AMERICAN PHYTOPATHOLOGICAL SOCIETY, PHILADELPHIA, DECEMBER 28, 1926

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Contents

Problems in connection with the introduction of methods of reducing losses due to stinking smut of wheat were discussed at the annual extension conference of the American Phytopathological Society which was held in Philadelphia on December 28, 1926 as a part of the winter program of the Society. Plant pathologists and agronomists from the United States and Canada and representatives of firms manufacturing copper carbonate dust were present and participated in this meeting.

Those who led discussions filed papers containing the gist of their talk with the writer who acted as chairman. In most instances men who were unable to attend sent in written statements and these were presented by other representatives from the State concerned. This willingness of those interested in the conference to put their thoughts in writing has made it possible to bring together important facts related to the control of stinking smut.

Stinking Smut in 1926

By R. J. Haskell, Associate Pathologist in Charge of Plant Disease Survey, Bureau of Plant Industry, U. S. Department of Agriculture

In the western part of the United States, that is from the Great Plains area westward, and particularly in the great Northwest where the form of bunt caused by Tilletia tritici exists and where soil infestation is an important factor, bunt is considered to be a very important, if not the most important, wheat disease. In the eastern United States, where the bunt is caused chiefly by Tilletia laevis and where soil infestation is not a factor, bunt has not usually been considered very important except in small local areas such as threshing rings where seed treatment has been neglected and where the disease has spread unchecked. In such areas, when bunt has become bad, farmers have changed or treated their seed and in that way have reduced or eliminated damage from the disease. During the past two or three years, however, something has happened to greatly increase the amount of bunt in the east and to cause it to spread from the local areas more or less generally over entire States.

Let us examine the Plant Disease Survey loss estimates that have accumulated during the past eight years. In 1922 bunt of wheat was apparently at a rather low ebb. The average reduction in yield for the country, according to the loss estimates, was only about one-half of one per cent, which was the smallest loss that has been estimated since figures have been obtained. The next year, however, the loss increased to 1.27 per cent and in 1924 it was more than double, reaching 2.72 per cent. In 1925 there was a reduction in the amount of bunt in the large producing sections of the northwest, but this was offset to a considerable extent by a continued increase in the soft red winter wheat areas of the east and in the hard red winter wheat areas of Kansas and Colorado, all of which resulted in the total loss for the country dropping a fraction of a per cent to

2.3 per cent. The prevalence of the disease in the east that year seemed to be correlated with unusually cool weather at the time winter wheat was germinating. The season that has just passed has shown still greater injuries especially in the hard and soft red winter wheat areas as well as in parts of the Northwest and California. When all of the estimates for 1926 have been received, it is probable that the total reduction in yield for the country on account of bunt will be the largest on record. This increase in the amount of disease has all been in spite of the control campaigns for seed treatment with copper carbonate that have been waged in many States. It must be remembered, however, that if these campaigns had not been conducted, the losses would have been fargreater than they actually were. The weather conditions during the past two seasons have been especially favorable for bunt infection and this, accompanied by a widespread occurrence of inoculum, has resulted in this wave of bunt on the crest of which we now seem to be riding.

The loss estimates for this year have as yet been received from only slightly more than half of the States. Many of these States are in the South where the bunt problem is not important. The reductions in yield, without considering the losses on account of dockage as reported to date, are as follows: Montana, 10 per cent; Kansas, 9 per cent; Colorado, 8 per cent; Pennsylvania, Nebraska and Idaho, 6 per cent; Virginia and Arizona, 5 per cent; North Carolina, Indiana, and Michigan, 4 per cent; Delaware, 3.5 per cent; Maryland and Oregon, 3 per cent; North Dakota, 2 per cent; New York, Illinois, Iowa, Missouri, Montana and Washington, Minnesota, Texas, Oklahoma and Arkansas, less than 1 per cent; Connecticut and Wisconsin, none.

The maximum percentage of infection in any one field reached very high percentages in some cases. In North Carolina one field was reported as so badly infested that the wheat was unfit for milling and its value for stock feed questionable. The maximum percentages of losses reported from individual fields were as follows: Nebraska, Kansas and Montana, 80 per cent; Pennsylvania and Virginia, 75 per cent; Maryland, Arizona and North Dakota, 50 per cent; California, 48.5 per cent; Iowa, 40 per cent; Colorado, 35 per cent; Delaware, 33 per cent; New York, 30 per cent; Indiana, 25 per cent; Missouri and Minnesota, 15 per cent.

All States reporting so far have rated the disease as more important this year than last, with the exception of Delaware, West Virginia, Illinois, Missouri, Wisconsin, Minnesota, North Dakota, Colorado, and Washington, which reported the same or a less amount, and all States have reported more than the average year except West Virginia, Illinois, Missouri, Minnesota, North Dakota and Washington.

Field Surveys

Three States, Pennsylvania, Maryland and Virginia, reported on actual field surveys that have been made and which have furnished a part of the basis for their loss estimates. In Pennsylvania a survey of 178 fields in 19 counties showed 6.25 per cent of the heads smutted. In Virginia 51 fields examined averaged 5.2 per cent infection; while in Maryland a survey of 685 fields revealed 1.5 per cent. In the latter State 307 of the fields, or 45 per cent, were free from the disease; 195 showed a trace; 84 contained from o.1 to 0.9 per cent; and 99 had 1 per cent or more.

Other Special Reports

Doctor Kirby has sent in a very striking graph showing reduction in yield on account of bunt in Pennsylvania annually since 1916. It shows an increase in amount of the disease since 1922 but especially since 1924. In 1925 the loss jumped from less than 1 per cent to 3 per cent, and in 1926 it doubled to 6 per cent.

In Nebraska, extension agronomists prepared a map in which the State was divided into three nearly equal parts by parallel north and south lines. In the eastern third of the State they estimate less than 1 per cent bunt; in the central part 3-5 per cent; and in the western portion from 5-80 per cent. The total estimate of loss for the State is placed at $3,000,000 which is equivalent to about 6 per cent.

In Colorado, bunt infection was reduced about one-half from 13 per cent in 1925 to 7 per cent in 1926. Apparently this was largely due to the extensive seed-treatment campaign conducted in the fall of 1925 and the spring of 1926. It is estimated that some 8,000 farmers were reached and that roughly 500,000 acres, or between one-half and one-third of the acreage, were planted with treated wheat.

Questionnaires to Grain Dealers

In two States, Illinois and Missouri, an idea of the distribution and abundance of bunt, as well as loss from dockage, was obtained by sending questionnaires to grain dealers. In Illinois, Doctor Tehon of the State Natural History Survey sent out 1,500 circular letters to members of the Illinois Grain Dealers Association asking for (1) the total number of bushels of wheat purchased, (2) the number of bushels of smutty wheat, and (3) the dockage applied to the smutty wheat. In summarizing the results, Tehon says:

> "Among the 207 replies there were 150 specific answers to the questions asked. A summary of them shows an actual money loss, either to growers or dealers, of $22,625.28 - this being the total dockage on 303,256 bushels of smutted wheat, an average of 7.4 cents per bushel. There were, however, 68,453 bushels of lightly smutted wheat which had no dockage -- thus bringing the total amount of infected grain to 371,709 bushels. Since

the marketing of 4,796,699 bushels was reported, smutty wheat constituted 7.7 per cent, and that on which dockage was applied 6.3 per cent."

A similar questionnaire was sent to dealers in Missouri by W. A. Archer and a summary of that work showed that a total of 3,830,900 bushels of wheat were purchased by those who replied, and that of them, 30,866 bushels, or 0.8 per cent, were smutty. A dockage of 9.1 cents per bushel or $2,834 was applied to this wheat. If all Missouri wheat was smutted in the same proportion, the hypothetical loss because of dockage for the State would be only about $14,509 or .06 per cent of the value of the crop. Figuring in the same way, the loss for Illinois would be about $181,000, or 0.7 per cent of the value of the crop.

From these figures it would appear that bunt was not a very important factor in these two States, especially in Missouri where less than 1 per cent of the wheat delivered was smutty, and where the percentage loss from dockage was only .06 per cent of the value of the State's crop.

Work for 1927

It is important to obtain each year as much information as we can on the prevalence and losses from bunt. Seed-treatment demonstrations should be based on survey. The two should go hand in hand in order that we may learn our results and effectively plan our control work. Extension pathologists in each State should spend some time each year on survey. It appears to me that the field-to-field surveys where a large number of representative fields are examined is perhaps the most useful, but this should be supplemented by inspection of threshed grain, questionnaires to dealers, consultation with federal grain inspectors, examination of market quotations and the like. In these ways we will be able to determine more closely what the various situations are and how to attack our problems to better advantage.

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Market Studies

At this point F. C. Meier, Extension Plant Pathologist, U. S. Department of Agriculture, called attention to recent studies of grain inspection records which he had made in cooperation with E. G. Boerner of the Bureau of Agricultural Economics, U. S. Department of Agriculture. This analysis of the inspection records of the Office of Federal Grain Supervision, confirms the results of field studies as outlined by Dr. Haskell. Figures showing the percentage of wheat receipts grading smutty were obtained from 144 markets for the period 1923 to October 1926. The following give some idea of the results secured:

(Less than 1 per cent not marked)

	1923-1924	1924-1925	1925-1926	July-October 1926
	%	%	%	%
Astoria, Oregon	52.	69.	32.	57.
Bozeman, Mont.	12.	19.	15.	25.
Denver, Colorado ...	21.	25.	36.	25.
Des Moines, Iowa ...	--	8.	7.	23.
Detroit, Mich.	--	--	10.8	12.
Duluth, Minn.	--	5.	17.	17.
Indianapolis, Ind....	3.	6.	--	6.8
Kansas City, Kan. ...	8.	11.	10.	25.
Kearney, Nebraska ...	4[illegible].	35.	54.	27.
Lawrenceburg, Ind*...	6[illegible].	37.	38.	40.
Lincoln, Nebraska ...	--	12.	26.	31.
Los Angeles, Cal. ...	20.	12.	15.	16.
Louisville, Ky.	5.	9.	--	4.
Ogden, Utah	13.8	21.	29.	31.
Oklahoma City, Okla.	1.	1.	--	7.
Omaha, Nebraska	14.2	26.2	39.	44.
Philadelphia, Pa.	3.	2.	10.	9.
Portland, Oregon	45.	60.	30.2	42.
Sacramento, Cal.	6.	9.	--	--
Seattle, Washington..	35.	41.	23.5	28.
Stockton, Cal........	26.	11.	6.	18.
Tacoma, Washington ..	42.	54.	30.	30.5
Toledo, Ohio	1.	3.	2.	2.
Baltimore, Md........	.8	2.3	8.5	11.

With a view to determining the extent of losses resulting from discounts at the city markets, a study was made of car-lot sales in Kansas City. This brought out the fact that during 1926 smut discounts caused losses at that point as follows:

July	$99,600
August	122,700
September	29,123
October	20,787

*High proportion of hard red winter wheat from western states.

The apparent decrease in loss during September and October is, of course, due to the fact that less wheat was handled in these months. The important point is the relation which these losses bear to all carloads of wheat handled during this period. It was found that these smut discounts were costing over $10.00 per car for all wheat handled.

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R. S. Kirby, Extension Plant Patholgist and Assistant Professor of Plant Pathology, Pennsylvania State College, attributed the tremendous increase in damage done in that State to change in date of planting which has come about during the past five years. According to Dr. Kirby, efforts to avoid Hessian fly have led to late planting which has favored the increase of smut.

L. E. Melchers, Head of the Department of Botany and Plant Pathology, Kansas State Agricultural College, stated:

"One thing is very definite with us in this connection, that is that wheat is being planted later very generally over the State and a difference of two weeks or so as far as soil is concerned is a very vital factor for smut infection. I am satisfied that in many cases the late planting of infested seed has generally spread a great deal of smut that would not have taken place if that same seed could have been planted sooner. Soil temperatures and moisture are more likely to be favorable for infection when the crop is sown late."

H. T. Güssow, Dominion Botanist, Ottawa, Canada, pointed out that in certain sections of Canada wheat smut was on the increase and that this development seems to be directly associated with soil temperatures. Referring to 1926 he said:

"We had an extraordinary cool spring and smut was more apparent. It is possible that weather conditions had something to do with the increase of smut."

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Smut As It Affects the United States Grain Standards

By J. H. Shollenberger, Milling & Baking Laboratory, Grain Division, Bureau of Agricultural Economics, U. S. Department of Agriculture

The United States wheat standards provide that smutty wheat shall be all wheat which has an unmistakable odor of smut, or which contains spores, balls, or portions of balls of smut in excess of a quantity equal to two balls of average size in 50 grams of wheat.

Two different methods are provided for designating such wheat smutty. By the one method the word "smutty" is added to and made a part of the grade designation, and by the other method the loss in weight caused by the removal of the smut from the wheat as ascertained by the use of a laboratory smut-scouring machine or by washing is assessed in terms of percentage against the sample as "smut dockage." The percentage of smut dockage so determined is stated in terms of whole per centum and half per centum. The percentage of smut dockage is added to the grade designation preceding the statement of ordinary or weed-seed dockage, if any.

The first method mentioned of grading smutty wheat is used east of the Rocky Mountains and the second or "smut dockage" method is used in the Rocky Mountain and Pacific Coast regions of the United States.

That the presence of smut affects the milling and baking qualities of wheat is an undisputed fact. Unless the smut is removed from the wheat before milling, the odor and color of the flour will be seriously affected. To remove the smut from the wheat so that a reasonably good flour may be made, it is necessary either to give it special scouring treatment or to wash it. If the wheat is very smutty, the washing method is the only one that will satisfactorily remove the smut. Wheat washers are costly and are expensive to operate. Approximately eight gallons of water are required to wash a bushel of wheat. This is a relatively large quantity of water, and its disposal often presents a very serious problem. Because of the quantity, filthiness and foul odor of the water coming from wheat washers, the health authorities in some sections of the country will not permit it to be run into nearby streams or into the public sewers. Under such circumstances, it is necessary to construct and operate a private sewage - disposal plant in connection with the washer. This adds to the cost of the cleaning and to that extent further depreciates the value of smutty wheat.

Few mills east of the Rocky Mountains are equipped with these washing machines, consequently the market for smutty wheat in this region is somewhat limited. Mills that are not equipped with the special scourers or washers for removing smut can not use smutty wheat unless it is only mildly affected with smut, and then only in very limited quantities. Where smut removing equipment is not available, the farmer generally has considerable trouble in disposing of his smutty wheat. However, in the Pacific Coast region, where smut is more prevalent and where practically all of the mills and terminal elevators are equipped with machinery for removing smut, the farmer finds very little difficulty in disposing of his

smutty wheat, providing he is willing to sell at the prevailing discounts for such wheat. In the Central West, due to the increased amount of smutty wheat during the past few years, many of the larger terminal elevators have installed washers for removing smut. This has materially benefited the farmer of that region by facilitating the marketing of his smutty wheat, and, no doubt, too, has made possible a higher price for such wheat.

In the process of removing the smut, the wheat is subjected to a rather severe abrasive action which results in the breaking up of some of the kernels and the peeling off of some of the branny coating of the kernels. This material, along with other fine material that may be present, is removed with the smut. Due to the presence of the smut in this material, it can not be ground and run into feed, as is customary with screening removed from wheat which is not smutty. Such material represents a direct loss to the miller and along with the extra expense involved in the cleaning of such wheat is given consideration in determining the commercial and milling value of smutty wheat in comparison with wheat that is not smutty.

O. F. Phillips, Chairman of the Board of Review, of Federal Grain Supervision, in a recent review of the outstanding grading problems of the last seven years, mentions smut as one of the four factors which are increasing and recurrent each year. In this connection, he cites an increase in smutty wheat in both the spring and hard winter wheat territories and states that the cost of this factor, together with three others he names, is annually costing the producers of grain millions of dollars.

The problem of correctly grading smutty wheat is oftentimes a very difficult one. Where smut is present in considerable quantity, there is no difficulty in recognizing that fact; but when it is present in small quantities, it then may be difficult to determine whether or not it is smutty within the meaning of the standards. Particularly is this true if the wheat has been "doctored" or reconditioned for the purpose of putting it outside the ban of the smutty grade designation. Some of the practices or methods used for this purpose merely cover up or distribute the smut spores throughout the wheat so thoroughly that it is difficult to measure the amount present. Also, the methods which aim to remove the smut may sometime fall short of expectations or change the condition of the grain to the extent that a grading problem of another kind is created. Mixing sound wheat containing no smut with natural smutty wheat or with treated wheat which had formerly been smutty is also one of the sources of a lot of inspection grief.

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Data presented in the accompanying table compiled for the period from 1918 to 1920 from more than 75,000 supervised car receipt inspections show a considerable variation in the prevalence of smut among the variousclasses of wheat as produced East and West of the Rocky Mountains for the crop years given. West of the Rockies smut was far more prevalent than east of the Rockies. With respect to class, smut was most prevalent East of the Rockies in the hard red winter wheat class and west of the Rockies in the soft red winter and white wheat classes. The proportion of the class thus affected for these crops ranged from zero per cent up to 42.3 per cent.

Percentage of Car-receipt Inspections of the Various Wheat Classes Grading as Smutty Wheat
(Based on data from more than 75,000 supervised car-receipt inspections)

Region	Crop Year	CLASS				
		Hard Red Spring	Durham	Hard Red Winter	Soft Red Winter	White
		Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Inspections east	1918	13.6	5.5	8.8	9.1	1.9
of Rocky Moun-	1919	.8	1.0	7.9	4.6	5.9
tains	1920	.3	3.4	14.5	1.8	5.2
Inspections west	1918	.4		22.2	34.5	15.7
of Rocky Moun-	1919	.3		14.7	41.8	43.2
tains	1920	.4		16.2	38.1	33.8

In a report of E. N. Bates of the Grain Division, Bureau of Agricultural Economics, in regard to smut on wheat as shown by Oregon State Grain inspection records for receipts of wheat at Portland and Astoria he shows that smut was assessed against 26.0 per cent of all the wheat receipt inspections of the 1920 crop, 41.5 per cent of those of the 1921 crop, 46.5 per cent of those of the 1922 crop, 46.0 per cent of those of the 1923 crop and 62.0 per cent of those of the 1924 crop. This would indicate an alarming increase in the amount of smutty wheat in that region. Other data presented by the same person shows there was an even greater increase, in that for this period, the number of inspections against which smut dockage in excess of .5 per cent was assessed, increased at an even greater rate. In other words, smut not only became more prevalent throughout the region served by these inspection points but also the quantity of it in the wheat increased as well.

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The Fungi Causing Stinking Smut of Wheat

By W. H. Tisdale, formerly Pathologist, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture

Stinking smut occurs wherever wheat is grown throughout the world. Two species of *Tilletia* cause the disease. Both species, *T. tritici* and *T. laevis* occur in the United States. *T. tritici* is confined in this country mainly to the Pacific Coast States and the two tiers of Northern States from Michigan west to the Rocky Mountains. *T. laevis* occurs throughout the country but much more abundantly east of the Rocky Mountains.

Stinking smut may be spread in many ways. The spores are carried on seed from smutty crops. The threshing ring and the combine serve to spread the disease. Wind dissemination is a very important factor, especially in the Pacific Coast States where soil infestation is abundant. There are many other ways by which the disease may be spread.

In recent years stinking smut has become increasingly more destructive in this country. A number of theories have been advanced regarding the possible cause of this increase in the amount of stinking smut. A decrease in the amount of seed treatment resulting from the low smut infection following the smut control campaign in 1918 to 1919 is probably responsible for some of the increase. The rapid decline in the price of wheat following the war, no doubt, caused considerable loss of interest in the wheat crop which might have resulted in less seed treatment. The entomologists in some States are recommending late sowing of winter wheat to avoid Hessian Fly injury. This late sowing favors smut infection, due to the lower temperatures. Maximum infection takes place at temperatures between 5 and 15 degrees Centigrade. Tisdale, Leighty and Boerner, working on the theory that *T. tritici* might have become spread throughout the East and that it might be responsible for the recent smut epidemics in that region, made a survey east of the Rocky Mountains in 1926 and found (unpublished data) that this species had not spread eastward from the area reported by Dr. Haskell to be infested in 1918. This does not preclude the possibility that one or more strains of *T. laevis* of highly pathogenic nature now occur in the East. Of the samples collected in the survey, *T. tritici* was found in none except durum wheat or durum mixtures. Where both species occurred in a sample, both durum and common wheats were present. In examining the samples considerable differences in the shape and appearance of spores of *T. laevis* were noted in different samples, and at times in different smut balls within the same sample. The spores of *T. tritici* varied from very echinulate to almost smooth. In fact the two species seemed to merge or overlap in this respect. This morphological variation may or may not be correlated with any physiological variations that may exist within the species.

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A Review of Some of the More Important Contributions to Our Knowledge of Bunt

By H. B. Humphrey, Senior Pathologist, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture

In the preparation of this paper, embodying as it does a summary of the results of recent research on the bunt problems, I must confess to having been unable to cover adequately the entire field as represented by the many publications that have issued from the laboratories of this and other countries during the past four years. Being unable to read either Russian, Japanese, Czecho-Slovakian, Hungarian or Polish, papers appearing in these languages unaccompanied by summaries in those languages with which I am familiar have not been included in this summary.

Even a casual review of the literature of the past few years will convince any investigator of the fact that a tremendous amount of time and labor has been devoted to the investigations of the relative merits of many alleged and real fungicides. Quite recently considerable impetus has been given to this type of investigation by virtue of the fact that a number of promising mercurial fungicides have been discovered, the preventive effectiveness of which surpasses that of such standard fungicides as formaldehyde, copper sulphate and corrosive sublimate. It is to be noted here, however, that up to the present moment virtually all of these more recently recommended mercurial fungicides are yet too expensive to influence those who comprise the buying public. The work of Mackie and Briggs and others in demonstrating the practical value of copper carbonate as a fungicide has done much to establish its worth as a bunt preventive, and to extend the popularity and secure the general adoption of the copper-carbonate-dust method of seed treatment for the prevention of this well-known disease of wheat. The following is a summary of some of the more important contributions to our knowledge of bunt and methods for its control that have appeared during the period 1923 to 1926, inclusive.

Hungerford, 1922, conducted some field-plot and greenhouse experiments on the relation of soil moisture and soil temperature to bunt infection in wheat. He found, under the conditions of his experiments, that relatively low soil temperatures, combined with a fairly high percentage of soil moisture, are conducive to stinking smut infection. (48 degrees to 54 degrees Fahrenheit and 22 per cent moisture).

Gibs, in some experiments conducted at Göttingen, in 1922 to 1923, to determine the combined effect of temperature and moisture on the incidence of bunt in certain varieties of wheat, obtained results confirming those of Woolman and Humphrey, 1923. His interpretation of the influence of soil moisture on the development of bunt, however, fails to take into account the importance of soil aeration. He states: "It might have been assumed that a high soil moisture content would increase the percentage of infection by promoting profuse mycelial development, but such was not the case. The incidence of disease was lowest in the very moist soil. This doubtless accelerates germination of the grain to an extent which materially curtails the susceptibility period." He fails to point out that this lowest incidence of bunt may have been due to inadequate aeration.

Heald and Boyle, 1923, state that seed treatment of such a resistant variety as Marquis is inadvisable when spring-wheat seeding is practiced, and that it now seems probable that even susceptible varieties may be spring-sown without disinfection, if macroscopically clean, with the assurance that the resulting percentage of smut will be very low.

Hurd-Karrer, 1925, in her investigation of the possible relation of cell-sap acidity to varietal resistance of wheat to Tilletia tritici, found that relatively low values for the immune Martin and the very susceptible Little Club varieties do not confirm Kirchner's statement that high titratable acidity of the juide of the wheat plant is directly and causally related to resistance to the bunt organism.

Gaines, in 1923, reports the results of studies conducted by him on the genetics of bunt resistance in wheat. He found that the most susceptible wheats, when sown under maximum infection conditions at Pullman, Washington, produced an average of approximately 80 per cent of bunted heads. He found further that the varieties Fortyfold, Red Russian, and Marquis have differing dilute resistances which reduce the amount of bunt by 10 to 25 per cent when these varieties are grown under maximum infection conditions. Descendants of crosses between those three varieties gave a cumulative resistance having a value of 30 to 60 per cent. The varieties Turkey, Florence and Alaska were found capable of reducing the amount of bunt 70 to 75 per cent when compared with standard susceptible varieties. These concentrated resistances also were found to be cumulative in effect when brought together by crossing. Some of the resulting progeny segregated for immunity.

Tisdale, et al., during the period 1918 to 1924, inclusive, conducted extensive cooperative studies in California, Oregon, and Washington, on the relative resistance of wheat to bunt. Seed of one or more strains of virtually all commercial varieties of wheat grown in the United States was inoculated with spores of Tilletia tritici and sown in nurseries at Davis, Moro and Pullman. Of the four commercial classes of common wheat, hard red winter wheats proved the most resistant, and the white wheats as a class were the most susceptible. One variety of white wheat proved virtually immune from bunt. Only two common wheats, Hussar and Martin, remained immune throughout these experiments. Ridit, a hybrid between Turkey and Florence, produced by Gaines of Pullman, has since become a valuable commercial wheat.

Results obtained by Stakman, Lambert, and Flor (1924), in their investigation of varietal resistance of spring wheats to Tilletia laevis, in the main confirm those reported by Tisdale, et al. for T. tritici. They found also that the vulgare wheats are to be classed as bunt-susceptible while the dicoccum and monococcum groups are resistant.

Briggs, reporting in the Journal of Agricultural Research for May 15, 1926, on his studies of the inheritance of resistance to Tilletia tritici, states that the varieties Hard Federation, White Federation, and Baart produced from 50 to 95 per cent of bunt infection throughout the five years of his investigation. During the same period Martin and Hussar remained immune. Immunity as manifested by Martin and Hussar was completely dominant.

Dobson, 1926, reported the results of experiments conducted by him on the toxicity of spores of Tilletia tritici, concludes that even when the spores of this smut are administered to animals in large doses, they produce no harmful effect on the health of animals. He states that from the point of view of the practical stock feeder, it may be safely accepted that grain infected with bunt may be fed without injury to animals.

In 1922-1923, Gassner reported the results of carefully conducted laboratory studies made by him in order to determine the relative merits of formaldehyde, Uspulun and Germisan applied as a solution. Wheat, heavily inoculated with bunt spores, was immersed in solutions of the three above-named fungicides. In another set of experiments, like lots of bunted seed were sprinkled instead of dipped. Following is a table summarizing the results in percentage of bunted plants for each treatment:

	Duration	With or without washing	Per cent of smutted plants
Formaldehyde			
0.05	1 hr.	With	16.1
0.05	1 hr.	Without	0.0
0.1	1 hr.	With	10.4
0.1	1 hr.	Without	0.0
Germisan			
0.05	1 hr.	With	11.05
0.05	1 hr.	Without	1.1
0.1	1 hr.	With	3.4
0.1	1 hr.	Without	0.0
Uspulun			
0.05	1 hr.	With	6.3
0.05	1 hr.	Without	7.8
0.1	1 hr.	With	0.0
0.1	1 hr.	Without	0.2
Water control	1 hr.	With	23.4
Water control	1 hr.	Without	19.5
Formaldehyde spray			
0.05			1.7
0.1			0.0
Germisan spray			
0.05			9.0
0.1			2.3
Uspulun spray			
0.05			24.6
0.1			18.7
Water(control)			21.0

Maquenne, 1924, discussing the recommendations of Vermorel for the treatment of seed wheat with copper acetate, or copper sulphate followed by lime, states that copper sulphate followed by lime favors, especially seed germination and the ultimate productivity of the wheat. The concentrations of copper sulphate used by Vermorel he found to be too strong. (Vermorel, 1924, recommended a 5-minute treatment in a solution of 1 per cent copper acetate) Maquenne further points out that any residue of copper adhering to the grain after treatment is neutralized by the soil, even though the latter may contain no carbonate of lime.

Sampson and Davies, in experiments conducted by Aberystwyth, Wales, in 1925, employed as fungicides dehydrated copper sulphate, copper carbonate containing about 50 per cent of copper, Uspulun, Germisan, and formaldehyde 1:320 and 1:480. Formaldehyde proved less effective than the better grades of copper carbonate. Control of bunt was accompanied by an improved stand and increased yield, the latter amounting in three instances to more than 100 per cent.

Briggs, 1926, reporting results of his investigation of the relative merits of more than 30 dust and liquid fungicides covering a period of four years, found the dust treatments preferable to liquid treatments chiefly because of their greater ease and convenience of application and less likelihood of seed injury. Of the 24 dusts employed, copper carbonate was, all points considered, the most satisfactory.

Neil, 1926, of New Zealand, conducted field experiments with dust fungicides including Uspulun, Semesan, copper carbonate, Corona 640. He compared them with bluestone, Germisan, and formaldehyde solutions and found that formaldehyde and $CuCO_3$ dusts gave best results.

Nagel, 1925, a German investigator, reporting on the effects of high temperatures during and after the treatment of seed with various disinfectants found that when spores of Tilletia tritici were immersed for one hour in solutions of varying strength of acetone-mercuric chloride, copper chloride, Segetan-neu, and Uspulun at temperatures of 18 degrees, 25 degrees, 30 degrees, 40 degrees, 45 degrees, and 48 degrees Centigrade, high temperatures (45 degrees - 48 degrees) coupled with adequate dosage of fungicides might prove injurious to the seed. The copper salts proved most injurious.

Tisdale, Taylor, Leukel and Griffiths, in November, 1925, reported the results of preliminary experiments involving the use of several of the more recently recommended smut fungicides. Among the most promising were the following mercury compounds - Chlorophol, Corono No. 620, Germisan, Semesan and Uspulun. Some of these disinfectants improved the germination of machine-threshed seed taken from uniform lots of pure varieties. In many instances the yield was increased. In some cases, however, the increase in yield was more than could be accounted for through seed treatment alone. Copper-carbonate dust gave the most satisfactory control of bunt..

Antonov, experimenting in Russia with a dust mixture of calcium carbonate and copper sulphate compared with formaldehyde, found that this dust combination controlled bunt and increased the yield.

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Resistant Varieties of Wheat as a Means of Reducing Losses Due to Stinking Smut

By E. F. Gaines, Cerealist, Department of
Farm Crops, Washington State College
and Experiment Station
(NOT PRESENT)

For the past twenty years the farmers in the winter wheat districts of the Pacific Northwest have been losing from one to five million dollars annually due to the ravages of stinking smut (*Tilletia tritici*, (Bjerk.) Wint.). Seed treatment does not control bunt in fall-sown wheat in this area, because the fallow land becomes covered with wind-borne spores during the harvest season, which infect the young wheat plants even though the best known methods of seed treatment have been used.

Sometimes more than half of the heads are bunted. The wheat which is threshed from such a field is difficult to market, and a smut dockage of from 10 to 20 cents per bushel is not uncommon. During threshing the dry smut dust may explode, setting fire to the machinery, strawstack, grain and surrounding fields. Hundreds of threshing machines and thousands of bushels of grain have been destroyed in this manner. Additional losses occur from sowing very early or very late as a means of avoiding infection. This practice may give a smut-free crop, but usually results in a smaller yield. Labor costs are higher if the seeding is done during the harvest season, and unfavorable weather conditions may make late seeding difficult.

For many years it has been a common observation among farmers that some varieties of wheat are more resistant to stinking smut than others. There have been many arguments as to whether more money could be made by growing the susceptible but prolific club wheats or the resistant but weak-strawed Turkey.

During the last ten years, the State experiment stations have taken up seriously the problem of developing or discovering satisfactory resistant varieties that would solve the smut problem. The Washington, Oregon, California and Idaho experiment stations have tested hundreds of varieties under conditions favoring maximum infection. The majority have been hopelessly susceptible, but there have been a few that have remained entirely free from bunt, while many have been intermediate in respect to resistance.

Resistant forms have most often been found in the hard red wheats, but buntless varieties of white wheats are also now well established. At the Washington Agricultural Experiment Station, four varieties have been immune in all tests since their first introduction. They may be named and briefly described as follows:

1. Martin (C.I. 4463A) is a soft, white, winter wheat grown since 1917 at Pullman. The original plant selection was collected by C. R. Ball at Aberdeen, Idaho, in 1916. This plant was taller and later than its mates. It probably also carried the factors for immunity, for all of its descendants have been bunt-free.

Except for its weak straw and late maturity, it would be a desirable variety for commercial production. The yield is equal to that of the more commonly grown winter wheats, and the grain is low in protein and water absorption, making it a good pastry flour when milled. The original Martin from which this strain was selected is quite susceptible to bunt.

2. Hussar (C.I. 4843) is a pure line, originating from a selection made by C. E. Leighty at the Illinois Station and distributed to the western Stations about ten years ago for the United States Department of Agriculture. Its immunity from bunt was observed at the Sherman County Branch Station at Moro, Oregon, in 1919, and corroborated at the stations in California and Washington the following year. In more than 50 tests since that time, it has remained bunt-less. It is a semi-hard, red, bearded wheat, similar to Turkey, but an inferior yielder and rather low in milling value. It has been used rather extensively as a parent in crosses with the more prolific susceptible varieties.

3. Sherman (C.I. 4430), a resistant strain of Turkey selected at Moro, Oregon, has shown slight infections in the Oregon experiments, but has remained bunt-free in all the inoculation experiments in Washington.

4. A strain of Baart was isolated in 1924 at the Washington Station which has remained buntless in 1925 and 1926. This plant appeared as a mutation in a row of susceptible Baart, the only difference between it and the parent strain being its immunity from bunt.

Some of the more resistant varieties have been crossed at Pullman, Washington, and hybrid segregates more resistant, as well as more susceptible than either parent have been isolated, indicating that immunity is due to the cumulative effect of multiple factors.

In 1916 a cross was made between Turkey and Florence. Both parents usually show from a trace to 10 per cent of bunted heads when inoculated seed is sown. They are classified as resistant, however, because under similar conditions such checks as Hybrid 128 and Pacific Bluestem produce as much as 80 to 95 per cent. Evidently the resistance of Turkey is caused by a different set of factors than that of Florence, for transgressive inheritance occurred, a number of bunt-free segregates as well as others very susceptible appearing. One of these segregates, Ridit by name, is rapidly becoming of commercial importance. It has been immune from bunt in the inoculation tests the past five years. In 1921 one plant showed a few smut balls on the side of one spike. Five other spikes on the same plant were bunt-free. The yield has averaged 4.8 per cent below Hybrid 128, the most commonly grown wheat of the northwest. By the fall of 1923, enough seed of Ridit was obtained to sow 28 acres on the College Farm, in addition to distributing pound packages to 167 farmers for trial in various communities. In 1925 and 1926 the Farm Crops Division of the Washington Agricultural Experiment Station distributed each year about 1,000 bushels of pure seed of this variety to farmers who were willing to take pains to keep it pure and increase it for their neighbors.

The unusually large amount of bunt occurring in the winter wheat in 1926 made the farmers more anxious than ever to get a smut-proof variety. The 200,000 to 300,000 acres sown to Ridit this fall indicates how rapidly it is replacing the old susceptible varieties. In fact, it is too rapid a shift from the standpoint of keeping the market balance between hard red and soft white wheat. Ridit is a fine looking hard red wheat and has taken many prizes at the local and State fairs in 1925 and 1926.

To offset this tendency, the Oregon Station at Moro has begun to increase White Odessa (C.I. 4655), a soft, white wheat that has produced high yields, is drouth-resistant and has been bunt-free in most of the inoculation experiments.

The Washington Station has also started to increase a white wheat, which is a segregate from a cross between White Odessa and Hybrid 128 made in 1920. Albit, as this new variety is called, is a compactum-like Hybrid 128 but has the immunity from bunt of White Odessa. It yields 8 per cent more than Hybrid 128, but in milling quality, stiffness of straw, etc., is much like it. In the fall of 1926, 30 acres of Albit were sown on the College Farm and pound packets of seed distributed to 220 farmers for testing in various sections of the State. Altogether it is the most promising wheat that has been released to farmers, and within the next ten years should go far toward solving the smut problem in the Pacific Northwest. It is likely that others will be developed in the meantime better suited to particular localities and conditions.

Wheat is grown from sea level to over 4,000 feet elevation and under rainfall varying from 8 to 100 inches, as well as under irrigation, in this Northwest territory, and it is too much to expect that a single variety would be adapted to all these varying conditions. The station workers in these States are continually testing new varieties and developing new hybrids, and bunt resistance is one of the varietal characteristics that is being insisted upon.

To illustrate the progress that is being made in this direction, the resistance tests at the Washington Agricultural Experiment Station at Pullman in 1926 may be given. Of 281 varieties and hybrid selections tested under conditions favoring maximum infection, 116 showed no trace of bunt, and 62 of these exhibited immunity under similar conditions in 1925 and 1924. The season of 1926 was especially favorable for bunt, as 36 of the susceptible varieties growing along side of these immune types produced above 70 per cent of bunted heads. Several of the hybrid selections showed a high degree of resistance, but were infected to some extent, 38 producing from a trace to 6 per cent. The remaining 91 varied in susceptibility, making a continuous series between the very resistant and very susceptible types.

The immune hybrids with but 9 exceptions came from crosses in which Hussar, Martin or White Odessa contributed the resistance, as shown in table 1.

Table 1. Distribution of varieties and hybrids according to their susceptibility to bunt, (Tilletia tritici (Bjerk,) Wint.). The size of the classes increases by an arithmetical progression of 2, thus emphasizing small differences in the more resistant segregates.

NAME	Limits of each class in per cent of bunt											
	0	1 to 2	3 to 6	7 to 12	13 to 20	21 to 30	31 to 42	43 to 56	57 to 72	73 to 90	91 to 100	Total Rows Tested
Winter Wheat												
Variety test	10	9	1	2	6	4	5	4	10	11	16	78
F$_5$ Sel.C X Wh.Odessa	2	2	1									5
" Wn.2426 X Sel.C	3	7	2									12
" Hybrid 128 X Wh. Odessa	15											15
F$_5$ Sel. C X Hussar	20	2										22
" Hussar X Wn. 2427	15	1										16
" Florence X Hussar	3											3
F$_4$ Hybrid 128 X Martin	25	1				1 (probably mixture)						27
" Martin X Ridit	7	1			1							9
" Martin X Triplet	2											2
" Hussar X Hybrid 128-	5											5
" Hussar X Aegilops cyl.	1			1								2
" Turkey X Rosen Rye			2			1			3		1	7
TOTAL	108	23	6	3	7	6	5	4	13	11	17	203
Per Cent	53.2	11.3	3.0	1.5	3.4	3.0	2.5	2.0	6.4	5.4	8.4	100.1
Spring Wheat												
Variety test	2	1	3	5	3	2	8	9	10	8	--	51
F$_6$ Marquis X Turkey	5											5
F$_4$ Baart X Florence					1	1	1					3
" Florence X Marquis	1	1	4	3	3	2						14
" Polish X Marquis					1	3	1					5
TOTAL	8	2	7	8	8	8	10	9	10	8	0	78
Per Cent	10.3	2.6	9.0	10.3	10.3	10.3	12.8	11.5	12.8	10.3	-	100.2

All selections beyond the sixth generation were listed as varieties. Thus the Turkey-Florence hybrids (Ridit, Selection C, and two other unnamed segregates) in the eleventh generation from the original cross were included in the variety test of winter wheats.

These figures are very different from those obtained ten years ago, when the first bunt immune bread wheat was discovered. Similar work is in progress in Oregon and California, and literally hundreds of immune hybrids are being tested for yield, milling quality, stiffness of straw, nonshattering and other characteristics of economic importance. Some of the more promising selections are being increased for distribution. Already 15 per cent of the total acreage in Washington as well as a considerable acreage in Idaho and Oregon, is sown to immune varieties. Within the next 10 years the bunt evil of the Northwest should be well under control through the development and introduction of the best of these immune hybrids.

The pathologists who have been working with stem rust will wonder why some physiologic form of bunt has not appeared to spoil this dream. The reply is, there has been a form found that will attack Martin, Hussar, White Odessa, and, to a very slight extent, Ridit. This strain came from the University of Halle, Germany. Seed of eight American wheats and four German wheats were inoculated with this German bunt and duplicate sets inoculated with local American bunt. The two lots of seed were sown October 30, 1925 in parallel rows. The results are shown in table 2.

Table 2. A comparison of German and American Bunt in Respect to Infecting power on eight local Northwest wheats and Four Wheats From Halle-Salle, Germany

Variety	Source of Seed	Source of Inoculum: America	Source of Inoculum: Germany
Hybrid 128	Pullman, Washington	92% bunt	98% bunt
Triplet	" "	79 "	84 "
Little Club	" "	91 "	100 "
Turkey	" "	2 "	36 "
Martin	" "	trace "	38 "
Ridit	" "	0 "	1 "
Hussar	" "	0 "	19 "
White Odessa	" "	0 "	71 "
Hohenheimer (Behaart)	Halle-Salle, Germany	36 "	1 "
Hohenheimer (Unbehaart)	" " "	33 "	0 "
Furst Hatzfeldt	" " "	54 "	15 "
Heits Dickkopf	" " "	42 "	0 "

Without exception, the German bunt proved more virulent on the American wheats but less virulent on the German wheats. This seems to be the first clear-cut case of bunt specialization, but it will not be surprising to find other forms in the various wheat-growing sections of the world. It is rather remarkable that this German strain has not become established in the United States, for there are many German settlements, especially in the Northwest, and these settlers have no doubt brought with them seed wheat from Germany. There is good reason to believe that it has not been established here, for Martin, Hussar, White Odessa and Ridit have been sent to about every station at home and abroad where stinking smut is a problem, and all reports received thus far show them to be immune except at Halle-Salle, Germany. The danger of introducing such a strain in the Northwest is so great that the plants were pulled quite green, dried in sacks and burned. On account of this danger, the tests will probably not be repeated at the Washington Station.

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C. E. Leighty, Agronomist in Charge of Eastern Wheat Investigations, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, discussed wheat breeding work, reviewing the experiments on resistance conducted at Davis, Calif., Moro, Ore., and Pullman, Wash., the results of which are contained in U. S. Department of Agriculture Bulletin No. 1299 (Tisdale, W. H., et al. Relative Resistance of wheat to bunt in the Pacific Coast States. U. S. D. A. Bul. 1299: 1-30, 1925); also the work of Gaines (Gaines, E. F. The inheritance of resistance to bunt or stinking smut of wheat. Jour. Amer. Soc. Agron. 12:124-132, 1920; and Genetics of bunt resistance in wheat. Jour. Agr. Res. 23: 445-479, 3 pl.1923); and that of Briggs (Briggs, F. N. Inheritance of resistance to bunt <u>Tilletia tritici</u> (Bjerk) Winter, in wheat. Jour. Agr. Res. <u>32</u>: 973-990, 1926). In conclusion he stated:

> "The plant breeder has open to him the methods of selection and hybridization. Selection has been effective in isolating resistant and immune strains which have served and will continue to serve as parents in crosses by means of which the good qualities of susceptible wheats will be combined with the resistant qualities. As work on the bunt problem progresses, doubtless numerous other resistant plants will be found in commercial wheats. These will provide resistant varieties and will furnish additional material for hybridization. It, therefore, appears entirely reasonable to predict, in the not distant future, the control of stinking smut by means of resistant varieties."

E. C. Stakman, Plant Pathologist, Minnesota State Agricultural College and Experiment Station, called attention to the fact that the plant breeder and plant pathologist must work together on this problem of resistance. It was his opinion that when one changes varieties of wheat there is danger of trading troubles. Bunt from the different parts of the United States and different parts of the world is different. It may be difficult to combine resistance for all.

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Effectiveness of Copper Carbonate in Controlling Stinking Smut of Wheat

By H. A. Rodenhiser, Assistant Plant Pathologist, Minnesota State Agricultural College and Experiment Station (Not present - represented by E. C. Stakeman)

In recent years copper carbonate has rapidly replaced the use of copper sulphate and formaldehyde for the control of stinking smut of wheat. The effectiveness of this dust in controlling stinking smut of wheat has been clearly indicated by a number of investigators.

At University Farm, St. Paul, for a period of four years, copper carbonate has reduced the amount of stinking smut of wheat to an average of approximately one per cent as compared with an average of 31 per cent of smut in the untreated plots. In 1926, 1.9 per cent of smut developed in the plots treated with a 20 per cent copper carbonate dust as compared with an average of 63.3 per cent in the untreated plots.

Results comparable with these have been published from 15 different stations in the United States and Canada for the years 1922, 1923, and 1924 (E. B. Lambert, H. A. Rodenhiser, and H. H. Flor - Crop protection Institute Paper). It was found that copper carbonate dust reduced the amount of bunt to less than two per cent, except in two trials. At Pullman, Washington, 5.9 per cent developed in 1923, and at Brandon, Manitoba, 7.3 per cent was reported in 1924. In most tests, however, the bunt was almost entirely eliminated.

It should be pointed out here that the effectiveness of the dust in controlling stinking smut depends to a considerable extent on two factors: (1) That the dust be applied in amounts not less than two ounces per bushel, and (2) That every seed be completely covered with a fine layer of the dust. Should the grain be treated with an excessive amount of dust, however, the seed would not be injured.

Formaldehyde has always practically eliminated stinking smut of wheat where soil infestation is not a problem. However, by use of this fungicide, losses through seed injury are sometimes greater than those they prevent by controlling the smut. This is especially true where wheat is sown in dry soil. Copper carbonate does not injure the seed. By a comparison of the data summarized in Table One it will be noted that, under Minnesota conditions, in several instances the yields were increased when seed was treated with copper carbonate dust. Furthermore, it will be noted that where the seed was treated with formaldehyde the yields were reduced. (See Table I)

Table I. Comparison of Yields of Untreated Wheat with Those Obtained from Wheat Treated with Formaldehyde and Copper Carbonate

Station	Year	Formaldehyde	Copper carbonate	Untreated	Difference in Yield over untreated: Formaldehyde	Difference in Yield over untreated: Copper Carbonate	Dif. in Yield Cop. Carbonate over Formaldehyde
St. Paul, Minn.	1922	20.9	28.5	26.3	-6.6	2.2	7.6
St. Paul, Minn.	1924	24.76	34.0	28.3	-3.54	5.7	9.2
Crookston, Minn.	1922	17.4	22.2	20.5	-3.2	1.6	4.5
Crookston, Minn.	1923	9.6	13.2	13.7	-4.1	-0.4	3.6
Morris, Minn.	1922	14.9	18.5	15.3	-0.4	2.9	3.3
Morris, Minn.	1924	16.93	22.33	22.63	-5.7	-0.3	5.4
Waseca, Minn.	1922	18.8	19.5	22.5	-3.7	3.0	0.7
Waseca, Minn.	1923	14.4	16.1	16.8	-2.4	-0.7	1.7

Ref. Crop Protection Institute reports for respective years.

In the results of the Cooperative Cereal Seed Treatment Project of the Crop Protection Institute, the plots from copper carbonate-treated seed yielded more than the checks in 17 of the 24 experiments and less than the checks in seven experiments. The formaldehyde plots yielded more than the checks in nine experiments less the checks in 14 experiments, and in one case the yield was identical. For the past three years the writers have treated wheat at the rate of five ounces of copper carbonate per bushel (5, 15, 20 and 52 per cent copper equivalent), and then sown the seed in rod rows to which had been added about one-half an ounce of the dust to the row. No seed injury has ever been noted in these tests.

Mackie and Briggs reported that any dilution of the pure copper carbonate reduces the effect of the dust. Within limits, this does not appear to be true, at least in the Hard Red Spring Wheat region where soil infestation is not a problem. At University Farm, St. Paul, the writers have tested various dilutions of the pure dust (in the per cents noted above) and found the 20 per cent equivalent dust to be just as effective as the 52 per cent equivalent dust. Copper carbonate dust having a copper equivalent of less than 20 per cent was found impracticable. This is naturally of importance to the farmers, since the 20 per cent dust may be purchased for approximately 20 cents less than the price paid for the 52 per cent copper carbonate dust.

In addition to the above, copper carbonate treatment has other advantages: since it is a dry treatment, it does not wet the seed, and it can be applied at any time before sowing. It eliminates the danger of freezing wet grain, of heating, sprouting, molding, makes it unnecessary to set the drill to make allowance for the swelling caused by liquid treatment, and it enables the farmer to treat his seed whenever he has time. For spring-grown grain, this is an advantage as the treatment can be made during the winter when the farmers are not particularly busy. It also enables the farmers to buy and use dusting machines cooperatively, as the period during which treatments can be made is long.

Copper carbonate has many advantages, but it has also a few limitations. Although good machines are on the market at a reasonable cost, farmers often make the mistake of trying to mix the dust with the wheat by hand or in homemade devices which do not keep the dust from escaping into the air. Consequently, a considerable amount of the dust will be inhaled, and, although the dust is not rankly poisonous, it has a nauseating effect on the one who is treating the grain.

The question of the effect of copper carbonate on the cups and bearings of the grain drill has arisen. Farmers and drill manufacturers have reported that the dust acts as an emery on the bearings, grinding and evening all parts that it comes in contact with. At University Farm, St. Paul, wheat was treated with 20 per cent copper carbonate dust at the rate of three ounces per bushel, and a quantity of the grain sufficient to sow 308 acres was run through a new Superior single-run force-feed drill. At the end of the run, the drill was given a careful examination and from all appearance was in first-class condition. No wear was apparent, and, while there was a slight coating of the copper carbonate over the cups and bearings, this did not seem to affect the free and easy operation of all moving parts. However, when grain was treated at the same rate with 52 per cent copper carbonate and a sufficient quantity had been run through the drill to sow 479 acres, the small drive sprocket and two gear hangers were broken and both drive shafts were twisted.

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Dr. Stakman, discussing the work done by Mr. Rodenhiser, called attention to the effect of copper carbonate on cups and bearings of grain drills. He made it plain that experience in Minnesota indicated that damage usually resulted only when coarse and gritty dusts were used. Dr. Kirby stated that, while greatest damage in Pennsylvania resulted from dusts containing a high percentage of copper, injury was also experienced when the lower grade materials were used.

M. W. Gardner, of Purdue University, at this point, in the absence of C. T. Gregory, Extension Plant Pathologist, Purdue University, presented the following paper:

Drill Injury Due to Copper Carbonate

By C. T. Gregory, Extension Plant Pathologist
Purdue University Agricultural Experiment Station

Extensive experiments with the copper carbonate treatment have never revealed injury to wheat seed in the form of impaired germination or reduced yield due to other causes. Our experience in Indiana further verifies this fact, but nevertheless a rather peculiar and dangerous difficulty has been experienced during the past two years, the breaking of drills while seeding copper-carbonate-treated wheat.

As has been previously reported in 1924, seven farmers in Howard and Bartholomew Counties reported the breaking of drills while sowing wheat treated with copper carbonate. In 1925, similar difficulties were reported from five counties and a close observation was made of two cases in Tippecanoe County.

During the early part of October, 1925, Paul Ford, a farmer in Tippecanoe County, broke the small bevel gear which drives the force-feed shaft. According to his own statement, he made two rounds on a 20-acre field on Saturday afternoon when he was stopped by the rain. He left the drill in the field, but covered it with a tarpaulin until Monday morning when he resumed the planting. He had not driven 30 feed when the gear broke, and later he found that it was impossible to turn the gears without first working the drive wheel back and forth. By careful manipulation he finally loosened the feed discs so that they could be moved. The treated wheat was all removed, the broken gear replaced and the wheel turned until all the free copper carbonate was removed from the machine. After running the treated seed through a fanning mill to remove all the excess copper carbonate, no further difficulty was experienced.

Ford found that the excess copper carbonate from the wheat had packed tightly around the force-feed discs. It is noteworthy that during the time that the drill remained in the field there was considerable rain. This fact appears to be important since our experiments indicate that this trouble is associated with moisture. It is evident too that an excessive amount of copper carbonate is liable to be detrimental since the excess cannot be retained on the surface of the seed and will lodge in the seed cups of the drill. However, Ford used only about two and one-half ounces of copper carbonate per bushel.

D. A. Baker, another Tippecanoe County farmer, succeeded in planting 20 acres of treated wheat, but discovered when he put the drill away that the shaft which drives the force-feed wheels had been twisted. The machine used is an old-fashioned type in which the power is transmitted to the feed-wheel shaft at one end rather than in the center. The torsion of the shaft began at the center of the drill and grew gradually greater until at the point where the power was applied it was twisted two and one-half times.

This injury has always been associated with but one type of drill. The so-called "internal or double run grain feed" is the only type in which injury has been observed in Indiana. The comparatively broad surface of the feed wheel and its close adjustment to the feed cup is apparently the explanation of the excessive friction which develops from the copper carbonate. One of the indications that this injury is from friction is that the "fluted feed" drills are not, so far as is known, ever broken while drilling the treated seed. The surface exposed where friction may develop is much less in this type of feed mechanism.

Various experiments have been conducted to determine the nature of this injury. The first test made was one adapted from concrete experiments and is known as the "slump test." It would appear that if the coating of copper carbonate on the wheat seed created friction, this fact would exhibit itself in a measureable way in the slump test. Accordingly a tin frustrum of a cone was made having these dimensions, 13 inches high, 4 inches across the top opening, and 8 inches across the bottom. The wheat to be tested was poured slowly into the cone and tamped down with a quarter-inch iron rod. The first evidence of a difference occurred during this tamping. In the untreated wheat the rod could rather easily be thrust to the bottom of the cone each time, even when it was completely filled with wheat. Under the same conditions with the copper-carbonate-treated seed it was difficult to force the rod more than a few inches into the wheat after the first few tampings. The cone was carefully filled to the top and leveled off with a straight-edge. After this the cone was lifted by hand but always by the same person and with, as near as possible, the same speed, since it was found that when the cone is lifted quickly the results are somewhat different. In every case Michikoff wheat was used, though it was found that a different variety makes little difference in the results.

The data indicates that under dry conditions the presence of copper carbonate on the surface of the wheat increases the friction from 23.4 to 37.8 per cent. Copper stearate, on the other hand, is apparently more oily and only increases the friction a little more than 16 per cent. The addition of talc to the commercial copper carbonate reduced the friction about 12 per cent.

Further laboratory tests were made to measure the power needed to sow treated and untreated wheat, but with electrical apparatus no constant differences could be measured. When the treated seed was left standing in the drill for 24 hours or longer, we could prove no evident increase in the power needed. These experiments indicate that while the wheat is dry the application of copper carbonate does not increase the friction sufficiently to cause injury to the drill.

Further experiments conducted this fall by three Purdue University seniors, have shown quite conclusively that moisture is the essential factor in causing injury to drills. When wheat was treated with copper carbonate and sowed immediately, there were no signs of a dangerous increase in power needed to turn the drill, but when this same wheat was left standing in the drill over night, after having been run through the drill the previous day, it was very difficult to loosen the feed wheels.

All the experimental evidence and the observations of farmers who experienced this trouble, indicate that the breaking of drills is associated with moisture. It is probable that treated wheat will cause no injury if sown immediately after being put in the drill, even though the weather is wet.

If the treated wheat is left over night or longer in the drill during wet weather, it will be necessary to tap the feed wheels to loosen any cementing action which may have occurred. Furthermore, the drill should be worked back and forth until the feed gears work freely, or the sudden excessive power needed may break some part.

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In the general discussion which followed this paper, representatives of the companies manufacturing dust participated. It was the feeling of those present that the matter of drill injury was only an incident in the development of the copper carbonate treatment, and that this injury would, in time, be circumvented. It was evident that all present were convinced that copper carbonate has come to stay.

While disucssing some of the difficulties connected with promoting the treatment, the matter of damage which might result from accidental sale of grain treated with copper-carbonate dust to mills arose.

Effect of Copper Carbonate on the Milling Quality of Treated Wheat

By J. H. Shollenberger, Milling and Baking Laboratory, Bureau of Agricultural Economics, U. S. Department of Agriculture

To determine the effect of copper-carbonate dust on the milling quality of wheat, two types of copper carbonate were used, namely, a pure basic copper carbonate containing 52-55 per cent of metallic copper and a dilute or "extended" form containing about 18-20 per cent of copper. These materials were applied in two ways, by the use of a commercial mixer and by the use of a home-made barrel mixer. In each instance approximately 2 ounces of copper carbonate were applied to each bushel of wheat. The samples thus treated were then compared with a sample of the same wheat untreated. Mr. J. R. Lintner, County Agent of Leesburg, Va., furnished the wheat and applied the treatment to the samples used in this experiment.

The two seed lots treated by means of the commercial mixer had a greener appearance of kernel than did the two lots treated with the barrel mixer, indicating thereby that more of the copper carbonate adhered to the wheat kernel. This was particularly true of the seed treated with pure copper carbonate.

Before milling, these samples were run first through a milling separator and then through a scourer. In treating the samples in this manner they were subjected to about the same kind and amount of cleaning that is accorded to wheat in commercial milling practice in its preparation for milling. The separator removed from the treated samples the loose copper carbonate and some that had adhered to the surface of the kernel, but not sufficiently to conceal the fact that they had been treated. The scourer brightened the treated grain considerably so that it was somewhat difficult to distinguish between it and the untreated grain.

When milled, the flours from the treated samples had a slightly greenish unnatural appearance and were lacking in creaminess of color characteristic of the flour from the untreated wheat. This was most pronounced in the flour from the sample treated with the pure copper carbonate applied with the commercial mixer, which seems to have made a more thorough application of the dust, causing it to be harder to remove by scouring.

The effect of the various treatments on baking quality are indicated by the results presented in the accompanying table. It will be noted from these results that the quality was materially affected, particularly in loaf volume and in color and texture of crumb. Instead of the slightly creamy appearance present in the bread made from the flour milled from the untreated wheat, the bread made from the treated wheats had a greenish appearance, faint for the two barrel-mixed wheats, but very distinct for the other two. In loaf volume the treated samples ranged from 140 to 540 cubic centimeters less than the untreated samples.

A similar reduction in color and texture of crumb was likewise noticeable in the treated wheats. In each of these three important quality factors, the sample treated with the pure copper carbonate in the commercial mixer gave him the lowest results.

Baking Results from Wheats Treated with Copper Carbonate

Type of copper carbonate used	Type of Mixer Used	Odor in Flour & bread	Water absorption of flour%	Volume of loaf c.c.	Color of crumb (score)	Texture of crumb (score)
Untreated	Untreated	Natural	53.6	1910	89.2	90.5
Dilute(20%-)	Commercial	Natural	53.6	1640	84.5	75.2
"	Barrel	Natural	52.9	1770	85.8	77.5
Pure (52%)	Commercial	Natural	53.6	1370	68.5	67.5
"	Barrel	Natural	53.6	1590	81.0	75.0

The greenish tint noticeable in the bread made from the treated samples indicated the presence of copper carbonate in the flour. Later its presence was verified by qualatative chemical analyses made by the Chemical Research Laboratory of the Grain Division, Bureau of Agricultural Economics.

These results indicate, not only that the milling and baking qualities of wheat treated with copper carbonate are seriously injured, but also condemn the use of such wheats for human consumption. Therefore, treated wheat should be used only for seeding purposes.

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The talk now turned to methods of introducing the treatment on the farm, papers being read by R. S. Kirby, R. A. Jehle and G. L. Zundel. These three, with statements prepared by W. W. Mackie of California, and C. E. Graves, Extension Plant Pathologist, Kansas State Agricultural College, are given below:

Methods of Applying Copper Carbonate Dust and Results from These Applications

By W. W. Mackie, University of California,
Berkeley, California

Copper carbonate dust as a practical effective fungicide for the control of bunt has been accepted everywhere but the methods for applying the dust vary considerably. Many of the common methods employed will be discussed.

The shovel method of mixing the seed and dust was early abandoned because of excessive waste of dust, inefficient mixing with resulting inefficiency in bunt control and injurious effects upon the person performing the task.

The barrel churn mixer or the small concrete mixer either in the home-made or manufactured form, has been used effectively especially for small lots of seed. This type is perhaps the best form for use at experiment stations where freedom from mixtures in seed is necessary. The box type (3,1) has on many farms been used because it can be made by any one handy with tools. The defects of both the barrel churn and box types include (a) loss of time in charging and discharging the container, (b) loss of dust and consequent excessive inhalation by the operator, (c) low outturn per hour, and (d) inefficienty in mixing seed and dust usually due to too rapid turning which establishes a practically motionless mass of seed in the center of the receptacle. By placing the axis diagonally across the barrel, or box, a splashing motion back and forth is established causing a thorough mixture which is absolutely essential for the success of the copper carbonate. The other defects appear impossible to remedy.

Continuous Treating Machines

Very early in the use of copper carbonate dust (1), continuous intake and discharge mixers received the attention of ranchers and others who had large quantities of seed to treat. The first types consisted mainly of spiral elevators into which dust was automatically injected. Many of these home-made machines are still in operation, but the better manufactured types are replacing them due to superiority in mixing and less loss of dust. The continuous mixer in all the types now on the market do not thoroughly discharge the seed. This retention of seed is the cause of seed mixtures when passing from one variety to another.

The gravity, or baffle (4), type of machine appears to be a good stationary type and has proven satisfactory especially in treating recleaned seed as fast as it emerges from the cleaners. Its capacity is large, little or no dust escapes and the mixing is satisfactory. The greatest objection lies in the failure of all of the seed to pass out of the machine while in operation. This objection has been overcome by replacing the slanting wooden baffles with smooth metal ones and by rounding out the angles.

Custom treating of seed is practiced with great success and is responsible for a very decided increase in the amount of seed treated. Two methods are employed, (a) the community itinerant plan where the outfit is owned by the farmers of the community and a regular charge made per ton with rebates or additional charges as shown by the books at the end of the season. One community in California has made a profit charging only $2.55 per ton including the cost of the copper carbonate. Another privately-operated outfit was successful when charging $2.50 per ton for the service. With both concerns the complete outfit travels to the farmers' granary, removes and treats the seed, resacks and returns it to the granary. This work is best done soon after harvest when the weather is favorable. Stored treated seed is not attacked by ordinary grain insects or mice as has been shown elsewhere by the author (5,6). Good treated seed may therefore be held safely in storage for a year or more.

Effect of Dusted Seed on Passage Through the Drill

The adhesive quality of copper carbonate dust very markedly retards the passage of seed through the drill. In order to sow the proper quantity of seed per acre, the measure of retardation should be known. An example of this is seen in the following figures prepared by Professor E. J. Stirniman, of Agricultural Engineering Laboratory at Davis. Seed of Hard Federation, a short-kerneled variety and Baart, a very long-kerneled variety, were treated with copper carbonate at the rate of two ounces per bushel and passed through a regular size 6-foot Kentucky grain drill with the following sowing in pounds of seed per acre.

TABLE I

Notch or Gear Number of Drill	HARD FEDERATION			BAART		
	Untreated	Treated	Per Cent Retardation	Untreated	Treated	Per Cent Retardation
10	154.3	119.7	22.7	162.5	118.3	27.1
9	144.7	114.0	20.8	154.0	108.6	29.5
8	132.8	105.2	20.4	144.0	100.0	30.5
7	123.7	95.9	22.7	134.3	91.5	32.1
6	113.2	89.1	21.3	124.0	83.6	32.3
5	102.5	79.2	22.5	113.7	76.3	32.7
4	90.6	69.9	23.5	103.4	68.9	33.9
3	79.5	64.6	18.9	92.5	60.6	34.7
2	68.4	53.7	21.0	80.5	51.0	36.2
1	57.0	49.5	14.0	70.5	44.1	37.1
		AVERAGE	20.7		AVERAGE	32.6

The average retardation for Hard Federation was 20.7 per cent and for Baart 32.6 per cent.

It is very evident from these figures, first, that there is no practical difference in the rate of retardation whether large or small amounts of seed are sown per acre, and, second, that retardation is markedly less for small seeded varieties.

Effect of Copper Carbonate Upon Smut Control and Yield

Each year at Davis the standard formulas (1) for chemical control of smut are demonstrated in field plots. The results for the 1926 crop are as follows. Hard Federation wheat was first inoculated with viable bunt spores at the rate of one part of spores to 1,000 parts of seed by weight. Tennessee Winter barley was heavily inoculated (the seed blackened) with viable spores of covered smut of barley. Portions of the seed wheat and barley were then treated according to the best accepted standard seed treatment methods as shown in Table 2.

TABLE 2

TREATMENT	Smut Attack Per Cent	Yields in Bushels per Acre
HARD FEDERATION WHEAT		
Smutted 1 to 1,000 but not treated	48.5	19.7
Formaldehyde 1 pt to 40 gal. water 15 min.	0.0	12.1
Bluestone (1 lb. to 4 gal.) 3 min. plus Lime (1 to 8) 5 min.	0.1	23.7
Copper Carbonate 2 ounces per bushel	2.5	30.7
TENNESSEE WINTER BARLEY		
Smutted Heavily (blackened)	Trace	40.6
Formaldehyde 1 pt. to 40 gal. water 15 min.	"	40.7
Bluestone (1 lb. to 4 gal.) 3 min. plus Lime (1 to 8) 5 min.	"	51.2
Copper Carbonate 3 ounces per bushel	"	61.6

The dosages of smut on both barley and wheat were very excessive and not likely to be duplicated on farms in general. Bunt was controlled satisfactorily but the barley smut behaved as usual for such experiments, giving no attack although every precaution was taken to secure viable spores and conditions satisfactory for the growth of this smut.

The effect of the formaldehyde on the wheat seed (1) was very destructive resulting in a poor stand with delayed germination and growth as compared with the check plot. The bluestone-lime treatment caused delayed germination and growth, but gave practically the same stand as the check plot. The copper carbonate-treated seed germinated promptly and appeared to be three days ahead of the check plot and two weeks ahead of the formaldehyde-treated plots. The stand was superior to the check. At harvest the copper-carbonate-treated plots matured earlier and yielded seven bushels per acre more than the next best plot (blue-lime.) Smut attack, of course, reduced the check plot yield.

The behavior of barley under various forms of seed treatment showed no marked difference in stand or early germination and growth. Only a few heads of smut appeared. The yields, however, showed that the copper carbonate-treated seed yielded 10.4 bushels per acre more than the nearest competitor, the bluestone-lime plots, as was the case with the wheat.

Literature Cited

1. HOFFMAN, A. H., and BELTON, H. L.
   1925. Machines for coating seed wheat with copper carbonate dust. California Agr. Exp. Sta. Bull. 391:1-16.

2. MACKIE, W. W.
   1919. Seed Treatment for the prevention of cereal smuts. California Agr. Exp. Sta. Cir. 214:1-8

3. MACKIE, W. W., and BRIGGS, F. N.
   1920. Fungicidal dusts for control of bunt. Science n. s. 52:540-541.

4. MACKIE, W. W., and BRIGGS, F. N.
   1923. Fungicidal dusts for the control of bunt. California Agr. Exp. Sta. Bull. 364:533-572.

5. MACKIE, W. W.,
   1925. Prevention of insect attack on stored grain. California Agr. Exp. Sta. Cir. 282:1-8

6. MACKIE, W.W., and BRIGGS, F. N.
   1926. Effects of wheat treated with copper carbonate upon the common house mouse (mus musculus). Phytopathology 16:629-632.

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Styles of Homemade Machines

By R. S. Kirby, Extension Plant Pathologist,
Pennsylvania State College

To be practical, any type of homemade treating device must, so far as is possible, be simple, cheap, durable, dust-tight and thoroughly efficient. Each of the many types of machines in use have attempted to fill these requirements as far as experience and materials allowed. Answers to a questionnaire sent out to the States using the dry copper carbonate for wheat treating, showed the following facts.

Batch mixers of either the diagonal or horizontal axis are universally recommended. Nine out of every ten states recommended that a wooden barrel or steel drum be used instead of a box container, since the box is the least durable and is the hardest to make and keep dust-tight. The States are about equally divided in opinion as to whether the axle should go diagonally or horizontally through the center of the container. It is generally recommended that a mixing or baffle board placed in the container will increase the efficiency of the treatment. Nearly one-half of the States recommend that a cement mixer or tumble butter churn be used where available.

The old tumble butter churn when supplied with one or two extra baffle boards is efficient, durable and dust-tight, but has the drawbacks of small capacity and more work per bushel of wheat treated. A cement mixer, when supplied with larger supplementary paddles and a tight cover, has the advantages of large capacity and power operation, but has the disadvantages of often failing to treat the wheat as thoroughly as the specially designed types, and of allowing considerable dust to escape, thus often causing severe sickness of the operators.

The diagonal axle type of machine seems to give the wheat a more even coating of dust but turns slightly harder than the horizontal axle types. Of this type opinion is divided as to the use of a wooden barrel or a steel oil drum. In most cases the availability of either type of container must determine which will be used. The steel drum requires more work with steel especially where the axle is welded in. On the other hand, the steel outfit is more durable, lighter in weight, and often more nearly dust-tight. In Pennsylvania a consideration of the various types of machines resulted in the universal adoption of the diagonal axle steel drum type of treating machine. Nearly 300 of this type of treating drums have been constructed during the past two years, at an average cost of about $3.50 each.

Any treating container should have a capacity of at least three times the volume of wheat to be treated in each batch, if efficient treating is to be done. Where the container is rotated by hand, growers seldom treat over one bushel at a time. For treating this amount of wheat, a 30-gallon container appears to be the most efficient. Where the outfit is power-driven, the size of the container may be increased up to several hundred gallons with proportionate increases in the amount of wheat that can be treated.

The first step in any treating operation appears to be the removal of the smut balls. Otherwise, the most efficient treater will fail to control the smut. Treated wheat runs harder through the drill, thus causing most of the smut balls to be broken. The spores thus liberated from the smut balls, often reach the bottom of the drill row without coming in contact with the copper carbonate dust and may cause considerable infection.

Failure to remove the smut balls before treating, in each case observed, increased the amount of smut in the succeeding crop from ten to twenty times.

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Commercial Machines for the Application of Copper Carbonate to Cereals

By G. L. Zundel, formerly Extension Plant Pathologist, State College of Washington

As soon as it was demonstrated that copper carbonate was a satisfactory fungicide for the control of bunt in wheat, the next problem to be solved was to find a satisfactory means of applying the powder to the wheat.

In 1922 the first machine for the application of copper carbonate to wheat was designed by the Experiment Station of the State College of Washington. This machine could be built by any farmer at a very low price. It consisted of (1) a wooden frame for support, (2) a cylindrical drum 21 inches in diameter and 36 inches long; and (3) a shaft passing end to end through the middle of the drum with a cogwheel on the outside at one end, which connects with another cogwheel attached to a crank. The ratio of the cogs on the drum wheel and the cog attached to the crank is one to four; (4) Three buffer mixers within the drum; (5) a slide door cut through the curved surface of the drum by means of which access may be had to the inside. The machine is $5\frac{1}{2}$ feet high.

This machine was soon manufactured by the iron works located at Colfax, Washington, and Walla Walla, Washington. Later the Calkins Machine Company and the Walla Walla Iron Works manufactured the first really commercial machines which were built on the general principles of the State College machine. Both commercial machines have self feeders for wheat and copper carbonate, and each have their different appliances to keep down the dust of the copper carbonate. The Walla Walla machine differs from the Calkins machine in that the revolving drum works inside of a stationary drum. Both machines are giving very satisfactory service, and are manufactured in several different sizes. The larger machines are run with electric power or by gasoline engines.

References

HEALD, F. D. and SMITH, J. J.
1922. The dusting of wheat for bunt or stinking-smut. Wash. Agr. Exp. Sta. Bull. 168.

KABLE, Geo. W.
1923. The O.A.C. Diagonal Axle Dusting Machine for treating wheat for smut. Ore. Agr. Ext. Bull. 381.

HOFFMAN, A. H., and BELTON, H. L.
1923. Machines for coating seed wheat with copper carbonate dust. Cal. Agr. Exp. Sta. Bull. 391.

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Method Demonstrations on the Control of Stinking Smut of Wheat with Copper Carbonate Dust

By R. A. Jehle, Specialist in Pathology,
University of Maryland

During the season of 1926, 73 method demonstrations on the control of stinking smut by treating wheat with copper carbonate dust were conducted in Maryland. These demonstrations were conducted jointly by the specialists in pathology and agronomy, and the county agents.

A homemade machine was designed from a 30 to 40 gallon coca-cola barrel and material which could be obtained in any hardware store. This machine was constructed so that it could be taken apart and placed in the back seat of a touring car. This machine, together with dust and literature on seed treatment, was taken by the specialists to the meetings. At each stop the construction of the machine was explained and several bushels of wheat were treated. The attendance varied according to the amount of smut in the neighborhood, the extent to which the meeting was advertised, etc. Sometimes only three or four interested farmers attended, while at other meetings there were 50 or more. As a result of these meetings, 98 barrels were known to have been constructed, 7,455 pounds of copper carbonate dust were used, and 45,050 bushels of seed wheat were treated.

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Control of Stinking Smut - Lectures at Meetings and Agricultural Trains

By C. E. Graves, Extension Plant Pathologist,
Kansas State Agricultural College

The one real fundamental principle underlying Agricultural Extension work is rural education. To me this means that we have a bigger job in this bunt-control program than just teaching farmers how to treat seed wheat. It means that besides demonstrating the method we should teach some facts concerning the life history of the bunt organism if the farmer is to progress in his own thinking and if we are to accomplish our purpose as extension workers.

It is fairly easy to attract the interest of any group of people when we demonstrate how to do anything. However most folks are too "lazy-minded" to care much about the why of things. Yet, if the farmers' knowledge of bunt-control is to increase to a point where he most intelligently applies the practice, he should know something about what he is working with, where it lives, when it attacks the wheat plant, and why bunt is more prevalent some seasons than others.

A knowledge of only how to treat seed wheat often works out disastrously in a bunt-control program. For example, 100 farmers may attend a seed-treating demonstration. We will take it for granted that a number of them go home and treat their seed wheat exactly as they have been shown. But during this particular season environmental factors are such that infection is light. At harvest these farmers observe that there is not a great deal more bunt in the fields planted with untreated seed than in the fields planted with treated seed.

Unless these men have learned why this came about, they are apt to seem rather unreasonable the next time the extension plant pathologist returns to that community. Therein lies the importance of a good, clear discussion on the bunt organism, its dissemination, life history, and especially the environmental factors which more or less govern its development.

The discussion itself must be simple and in terms that the farmer can easily understand. If the points made are not understood clearly the farmer leaves the meeting with only hazy ideas and perhaps with some wrong impressions.

In using examples for comparison we must use instances which are familiar to the farmer. I know from experience that it is easier to say "use simple terms" than it is to think of simple terms to use. I am going to tell you some of the terms that I used last summer at farmers' meetings and on our two Wheat Trains which were attended by 158,000 people of all ages and degrees of intelligence. These examples may seem crude, but they convey the idea.

First, there is the term "spore." Few farmers are acquainted with this term, but if one is to get them thinking intelligently about bunt control they should have a definite conception of the spore's function in the life history of the bunt organism.

I like to speak of "smut spores" as "smut germs," because the word "germ" is one with which they are familiar. It also sends home the idea that we are talking about a disease and not something caused by the weather.

I believe it pays to take time to explain that this particular type of germ is one we call a spore. I do this because I hope that some day we may use this term and many others and know that we are better understood than we now are when we use simple terms.

It is a little more difficult to explain how the organism lives as a parasite in the wheat plant. The term "parasite" is not clearly understood by the

most people. Nearly every farmer has had experience with intestinal worms in swine. They know that these worms get their nourishment from the pig. I often compare the plant parasite inside the wheat plant with the animal parasite in the pig. This illustration is probably far-fetched, but it conveys the idea of parasitism fairly well.

The hardest job of all is to explain the environmental factors and their relation to spore germination. If the discussion is not clearly understood the farmer is apt to turn to his neighbor and say, "Well, it's all in the weather after all."

Most farmers have had experience with an incubator and the hatching of eggs. They know that if temperature and moisture conditions are not right, many of the germs in the eggs do not develop. I tell them that these smut "germs" must have a cool, moist environment if they are to develop just as the germs in the eggs in the incubator must have a warm, moist environment if they are to develop. You can always see the faces in the audience light up with understanding after this explanation. Almost invariably some one will make the statement that his experience coincides with what has been said. Last summer on our Wheat Trains many farmers stated that they had observed considerably more bunt in fields planted about the time of a cold rain they had about the first of October. Fields planted earlier were not so badly infected.

Another important part in the discussion of bunt-control is the bringing in of local demonstrations. In nearly every community someone has had a successful experience with seed treatment. It adds local color to give the man's name and his experience. Also the crowd has more confidence in an example of bunt control when taken from the local community.

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Sources of Machines and Dust

In preparation for this meeting D. E. Stephens, Agronomist and Superintendent of the Experiment Station at Moro, Oregon, rendered valuable service in collecting data with reference to machines which have been put on the market for use in treating seed with copper carbonate. This list and a list of companies manufacturing copper carbonate dust are as follows:

(The inclusion of names in this list implies no endorsement by the Department of Agriculture or any of the State Agricultural Colleges represented at this meeting, nor is any discrimination intended if the name of any firm has been omitted)

Dusting Machine Manufacturers

Gibson Warehouse Company,
Madera, California.

The Grain Pickler Co., Ltd.,
Regina, Sask. Canada.

Calkins Machine Company,
Spokane, Washington.

Lindsey Brothers,
Minneapolis, Minn.

Mr. Frederick Steigmeyer,
Boston Land Co.,
Westhaven, California.

Owens Manufacturing Co.,
Minneapolis, Minn.

Schmeiser Manufacturing Co.,
Davis California.

Twin City Separator Company,
Minneapolis, Minn.

Dandy Duster Sales Co.,
Spokane, Wash.

Dust Spray Manufacturing Co.,
1224 West 9th St.,
Kansas City, Mo.

Walla Walla Iron Works,
Walla Walla, Washington.

C. Allert,
Ritzville, Washington.

Standard Fanning Mill Co.,
Minneapolis, Minn.

Carter Mayhew Manufacturing Co.,
665-19th Avenue, N.E.,
Minneapolis, Minn.

Link Belt Manufacturing Co.,
Fargo, North Dakota.

American Grain Separator Co.,
Erie and Essex Sts., S. E.,
Minneapolis, Minn.

Farm Machinery Sales Co.,
Spokane, Washington.

Copper-carbonate Dust Manufacturers

Stauffer Chemical Company,
624 California St.,
San Francisco, Cal.

Nichols Copper Co.,
25 Broad St.,
New York, N. Y.

Nitrate Agencies,
Bayonne, N. J.

M. Ewing Fox Company,
136 & Rider Ave.,
New York, New York.

California Chemical Spray Co.,
Watsonville, Cal.

Mountain Copper Co., Ltd.,
332 Pine St.,
San Francisco, Cal.

Pittsburgh Plate Glass Co.,
Milwaukee, Wis.